Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Forces and Motion: Basics

A **force** is simply a push or pull on an object. In order to overcome inertia and accelerate an object (change its speed or direction), you must exert a force. When more than one force is acting on the same object, we combine all of the forces into a single vector called the **net force**. Forces in the same direction are added together. Forces in opposite directions are subtracted.

*Procedure:*

*a) At phet.colorado.edu, run the Forces and Motion: Basics simulation in HTML5.*

*b) Click on the Net Force tab.*

*c) Check the boxes in the top right corner labeled Sum of Forces and Values.*

*d) Drag individuals from the bottom to the rope in order to fill in the blanks below.*

1. Each small person can pull with a force of \_\_\_\_\_\_ newtons. Each medium-sized person can pull with a force of \_\_\_\_\_\_ newtons. Each large person can pull with a force of \_\_\_\_\_\_ newtons.

*e) Complete the table below. To calculate the acceleration of the candy cart, divide the net force by the mass of the cart. Formulaically… a = Fnet / m*

*Assume the cart has a mass of 25 kg.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Scenario | Left Team | Right Team | Force to the Left | Force to the Right | Net Force | Acceleration |
| 1 | 1 small | nobody | 50 N | 0 N | 50 N to the left | (50 N / 25 kg) = 2 m/s2 to the left |
| 2 | 2 small | 1 medium |  |  |  |  |
| 3 | 1 small,  1 large | 1 small,  1 medium |  |  |  |  |
| 4 | 1 large | 1 small,  1 medium |  |  |  |  |
| 5 | 2 small,  1 medium,  1 large | 1 medium |  |  |  |  |

*f) Draw the force diagram for each scenario. Do not include gravity or the normal force. Quantitatively show the magnitude of the forces by using a scale of 1 cm = 50 newtons.*

*Scenario 1:*

*Scenario 2:*

*Scenario 3:*

*Scenario 4:*

*Scenario 5:*

2. Scenario 3 had a lot more people than scenario 1. So, why didn’t the cart accelerate faster in scenario 3 than in scenario 1? *Hint: Which force determines acceleration? How did the value of that force compare between scenarios 1 and 3?*

3. In every scenario, the left team was different from the right team. So, why didn’t the cart move in scenarios 2 and 4? *Hint: What did the force from the left team and the force from the right team do to each other?*

4. When the cart did not accelerate, the net force was always \_\_\_\_\_\_\_ newtons.

*g) Open the Acceleration tab at the bottom of the screen.*

*h) Check the boxes next to Sum of Forces, Speed, and Acceleration in the top right corner.*

*i) Investigate the force vectors and relationship between acceleration and speed by applying a force of 300 or 400 newtons until the box is released, then -300 or -400 N.*

5. Why doesn’t the speed gauge read anything below zero, even when the box is moving to the left? *Hint: Speed is a scalar quantity. Velocity is a vector.*

6. When the applied force and friction force act in opposite directions, the net force vector is small. When the applied force and friction force act in the same direction, the net force vector is large. Why?

7. The **friction force** is always in the ( same  /  opposite ) direction as **the direction the box is moving**.

8. The **net force** (green) vector is always in the ( same  /  opposite ) direction as the **acceleration**.

9. Without an applied force, the net force is ( less than  /  equal to  /  greater than ) the friction force.

*j) Remove all friction. Push the box for a few seconds, then observe its motion.*

10. Without a friction force, the net force is ( less than  /  equal to  /  greater than ) the applied force.

11. When you push the box with a **larger applied force**, the **acceleration** of the box is ( lesser  /  greater ), which means **the speed changes** ( more slowly  /  more quickly ) than when you push with a smaller applied force.

12. After the box is released in a frictionless environment, the **net force** on the box is \_\_\_\_\_\_\_\_ newtons, and the **acceleration** is \_\_\_\_\_\_\_\_ m/s2. With no acceleration, the **speed** is ( constant / changing ).

13. Newton’s law of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ tells us that without friction, the box will slide forever.